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Bruhat Bengaluru Mahanagara Palike

DETAILED PROJECT REPORT

CONSULTING SERVICES FOR PREPARATION OF DETAILED PROJECT REPORT FOR

Name of Work: Improvements to roads and footpaths at Yelahanka New Town 4th Phase 5th Phase and Industrial Areas in ward no 03 of Yelahanka New Town Sub Division (Package no. 14)

COST OF THE PROJECT: 600.00 LAKHS

Submitted To:
The Executive Engineer,
Yelahanka Division,
B.B.M.P, Bangalore.

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Chapter -1
INTRODUCTION

Chapter -1

INTRODUCTION

1.1.1 General

Bengaluru is the capital of India's southern Karnataka state. The center of India's high-tech industry, the city is also known for its parks. It is also known as the Garden City because of its many beautiful gardens and parks. By Cubbon Park, Vidhana Soudha is a Neo-Dravidian legislative building. Former royal residences include 19th-century Bangalore Palace, modeled after England's Windsor Castle, and Tipu Sultan's Summer Palace, an 18th-century teak structure.During the last couple of decades, city has witnessed drastic increase in population, change in land use pattern of the city, life style of the people and their commuting habits and the revolutionary changes that has taken place in the automobile industry. This has contributed to the growth of vehicular traffic in an enormous way.

1.1.2 City Background

It also called the Silicon Valley of India , because of the high concentration of IT industry. Bangalore is rated to one of the fastest growing cities in Asia with a current population of more than 10 million. During the last couple of decades, city has witnessed drastic increase in population, change in land use pattern of the city, life style of the people and their commuting habits and the revolutionary changes that has taken place in the automobile industry.

1.1.3 Population

The Bangalore city population is currently more than 12.5 million and increasing in a forward march. The lifestyle of the citizens is changing day to day due to globalization and introducing of new brands in all sector. Bangalore, the fastest growing city of India, comprises of a dynamic blend of people, belonging to various religions, castes and communities. With the introduction of information technology in the city, it has assumed an international character. IT professionals not only from the various parts of India, but also that of the world, are migrating to the city. This has led to Bangalore becoming more like the melting pot of various cultures. Read on to know more about the people and lifestyle of Bengalooru, India.

1.1.4 Traffic growth

What adds to the traffic pressure in Bengaluru in particular is that there is very little scope for expansion of roads and the need to use existing roads for smooth movement of vehicles is even more pronounced. It thus becomes mandatory for the administration to ensure better parking facilities. So far, the government and the BBMP have not taken this issue seriously

and now the situation is such that it needs to be addressed seriously and effectively. Rapid population growth because of IT and other associated industries in Bengaluru led to an increase in the vehicular population to about 1.5 million, with an annual growth rate of 7-10%. With the increase in population and the expansion of the city, the problem of connectivity of the populace has arisen. Quite obviously personalized modes of transport have grown at a tremendous rate and two wheelers along with the cars almost comprise 90% of the total registered vehicular population in the city. Two wheelers constitute more than 70% of the total volume, while cars comprise 15%, autos 4% and the remaining 8% includes other vehicles such as buses, vans and tempos.

Project Location

The Project includes **Improvements to roads and footpaths at Yelahanka New Town 4th Phase 5th Phase and Industrial Areas in ward no 03 of Yelahanka New Town Sub Division (Package no. 14)**. The Project area is in Yelahanka Assembly constituency, Bangalore. The Project stretch includes main roads and cross roads of Ward 03. By considering the above reasons following roads are taken up for Development with Asphalting depending upon the site scenario.

Key Map of the roads proposed is enclosed in **Annexure A.1.1.**

M/s. SILICON CONSULTING ENGINEERS is entrusted by BBMP to carry out the work of Preparation of Detailed Estimate and Report for the above said work.

Accordingly we **M/s. SILICON CONSULTING ENGINEERS** have commenced the consultancy works as per the scope of services described in the RFP document.

1.2 Scope of Work

The Scope of Services of the Consultancy includes the following:

Inventory and condition surveys for alignment.

- Engineering surveys and investigations
- Improvement to the existing pavement and drains, such as horizontal and vertical alignment, curve straightening, rising of the road level in low lying areas above the HFLs, concentric widening / eccentric widening etc.
- Design of Pavement.
- Design of lateral side drains and Cross drainage works such as culverts etc
- Rate analysis of scheduled items, BOQ and Cost estimates.
- Final Detailed Project Report and final drawings

❖ Photos of the project roads

1.2.1 Engineering surveys and investigations

The engineering surveys and investigations shall be divided into the following components:

- Topographic, alignment and land use survey
- Inventory survey
- Bridge condition survey
- Soil, geo-technical, material, hydrology and drainage surveys

1.2.1.1 Topographic, alignment and land use survey

The activities and Deliverables forming part of the topographic, alignment and land use survey are described below:

(a) Divide the Project Highway into various stretches as per terrain classification.

(b) Identify sections of Project Highway which require raising. Such sections will be identified with attention being paid to the previous history of submergence and the extent to which the sub grade is likely to be affected by the capillary action if the section is not raised.

(c) As far as possible, the existing alignment would be retained subject to the following requirements:

(d) Identify stretches where the gradients are steeper than the ruling gradient for the relevant terrain condition. Work out and prepare an improvement plan for the vertical alignment in such stretches.

(e) Identify stretches involving construction of new bridges and other structures including those requiring reconstruction and their approaches. Work out proposal for location of such structures and alignment of approaches.

(f) Based on the improvement plans of horizontal and vertical alignment worked out as a result of tasks in prepare alignment plans, cross-sections of the entire Project Highway.

(g) A set of cross-sections of the existing road at equal intervals for each section shall be provided by the Consultant. These cross-sections along with proposed improvement plan and preliminary design shall form the basis of preparation of indicative BOQ for the Project Highway.

1.2.1.2 Road inventory survey

(a) An inventory of road, culverts, bridges and other structures like railway over/under bridges, flyovers (grade separated structures), underpasses and overpasses.

(b) Identification of stretches of the Project Highway which -

(i) are affected by frequent flooding;

(ii) are subjected to water logging;

(iii) pass through black cotton soil area;

(iv) pass through marshy area; or

(v) pass through weak soil stratum

(c) Identification of sections in cutting.

(d) Identification of culverts requiring:

(i) Reconstruction (all culverts which are structurally distressed shall be reconstructed as new structures).

(ii) Widening (all existing culverts which are not to be reconstructed shall be widened equal to the roadway width).

(iii) Repairs and/or rehabilitation along with preliminary proposals.

(iv) New construction

1.2.1.3 Road condition survey

The Consultant shall undertake a survey of the visual condition of the pavement and shoulders of the Project Highway. The Consultant should also report if distresses are observed in the pavement and shoulders. It will also identify sections requiring reconstruction.

1.2.1.4 Structure condition survey

(a) The Consultant shall carry out a detailed inspection of every structure

(b) For each structure, the Consultant shall indicate the distresses observed, if any, in respect of various components of the structures. On the basis of the distresses observed, the Consultant shall divide the structures into the following categories:

(i) structures requiring reconstruction immediately as part of first stage development (all such structures shall be provided as new structures);

(ii) structures where distresses are not so severe and reconstruction can be postponed to a subsequent stage say for a period of 7 to 8 years, if any major repairs are required in the meantime, these shall be so indicated for each such location;

(iii) Structures requiring repairs and/or rehabilitation (for such structures indicate preliminary proposals for repairs and/or rehabilitation);

(iv) Structures requiring widening (for such structures indicate widening methodology); and

(v) Structures that shall be retained.

1.2.1.5 Soil, geotechnical, hydrology and drainage surveys

(a) The characteristics of the existing soil of the Project Highway.

(b) The determination of sub grade CBR (soaked) of the Project.

(c) Benkleman Beam Deflection measurements on the Project Highway.

(d) Preliminary hydraulic data for structures, design discharge, HFL, LWL, etc. with a view

to checking adequacy of existing waterway.

(f) A broad assessment of the drainage condition and requirement of the Project Highway.

1.2.1.6 Road signs, safety devices

(a) The Consultant shall propose provision of Road Signs, Pavement Markings, Safety Barriers, Railings, Delineators.

(b) The Consultant shall propose overhead signs on the Project Highway and provide an outline of the same giving size and location.

1.3 Project cost

The Consultant shall work out indicative BOQ of various components and prepare cost estimates of the Project Highway with a break up of cost for each component separately.

1.4 Organisation of Detailed Project Report

The Methodology, as detailed in the Project proposal, it has been followed for carrying out the necessary Investigations and for the Preparation of Detailed Estimate and Report.

This Report includes the following.

- Chapter 2: Investigation & Surveys
- Chapter 3: Reconnaisance survey
- Chapter 4: Design Standard & Specification
- Chapter 5: Design & Proposals
- Chapter 6: Technical Report
- Chapter 7: Project Cost Estimates

Chapter -2
INVESTIGATION & SURVEYS

Chapter -2
ENGINEERING SURVEYS AND INVESTIGATIONS

2.1 General

Various surveys and investigations that are the essential inputs for detailed engineering design are detailed in this chapter. All the relevant maps / data / details available with the concerned departments have been collected, compiled and reviewed. Particular attention has been given to past / historical data / reports. A review of the past data available in the various studies has been listed out and such available data has been made use of, after updating / augmenting the data wherever necessary. The data as collected has been made use of in analysis, design, formulation of improvement proposals and costing. The activities have been performed on several fronts fully complying with the requirements. The activities that are carried out are brought out hereunder.

The various engineering surveys / investigations of the road sections include:

- Reconnaissance Survey.
- Visual Topographical Survey.
- Road Inventory Survey.
- Pavement Condition Survey.
- Visual Condition Survey.
- Bridge condition survey
- Soil, geo-technical, material, hydrology and drainage surveys

2.2 Reconnaissance Survey

Reconnaissance Survey of the road, considered for improvements, has been carried out to identify the general condition of roads, drains, culverts and bridges for further surveys / investigations, to understand kind of establishments along the stretches of roads and to work out land acquisition scheme. Making use of the observations / data collected during reconnaissance survey, detailed schedule for surveys / investigations required for the project has been finalized.

2.3 Visual Topographical Survey

Topographic Survey has been conducted all along the corridor by physically measuring the Road Width, Footpath Width, Drain Width, Alignment of Road and with the aid of Google Maps.

2.4 Road Inventory Survey

A detailed inventory and condition survey of road sections has been carried out by making use of well structured inventory data format. It was compiled in tabular form, developed using Excel computer software. Various data collected during the road inventory broadly include.

- Type of terrain.
- Land use.
- Carriageway width.
- Type of surfacing.
- Shoulder, Median, Drain (tertiary / shoulder), Footpath - type and width.
- Road Geometry.
- Road Furniture.
- Illumination.
- Salient Buildings & Structures.
- Road Intersection(s) and their details.
- Land width (RoW).
- Culverts, bridges and other structures (type, size, span arrangement and location).
- General drainage conditions.

2.5 Pavement Condition Survey

The Pavement Condition Survey has been carried out in accordance with IRC Guidelines. All surveys and investigations have been carried out with the following objectives:

- To have an up to date record of road assets.
- To have a clear understanding of road side features including land use, drainage characteristics, etc. and
- To assess the condition and strength data for developing improvement proposals and related designs.

2.5.1 Visual Condition Survey

Visual Condition Survey of the road sections has been carried out by travelling along the patching, rutting, pot holes, edge breaking, etc. by visual observations in a well structured data format. The data so collected has been compiled and presented (kilometer wise) in the form of tables for easy understanding. This data has been used to assess the pavement condition.

2.5.2 Soil, geotechnical, material, hydrology and drainage surveys

(i) The activities and Deliverables forming part of the soil, geotechnical, material, hydrology and drainage surveys are described below:

(a) The characteristics of the existing soil of the Project road.

(b) The determination of sub grade CBR (soaked) Project road.

(c) Benkelman Beam Deflection measurements on the Project road for overlay stretches.

(d) Preliminary hydraulic data for bridges, design discharge, HFL, LWL, etc. with a view to checking adequacy of existing waterway.

(e) A broad assessment of the drainage condition and requirement of the Project Highway.

(ii) Road signs, safety devices

(a) The provision of Road Signs, Pavement Markings, Safety Barriers, Railings, Delineators, Chevron Markings, Traffic Attenuators. It shall also include Crash Barriers for existing bridges.

(b) Overhead signs on the Project road and provide an outline of the same giving size and location.

Chapter - 3
RECONNAISSANCE SURVEY

Chapter -3
RECONNAISSANCE SURVEY

3.1 General

The Reconnaissance survey is an extensive study of an entire area that might be used for a road or airfield. Its purpose is to eliminate those routes or sites which are impractical or unfeasible and to identify the more promising routes or sites. Existing maps and aerial photographs may be of great help.. The activities that are carried out are brought out hereunder.

The various engineering surveys / investigations of the road sections include:

- Study of topographical survey sheets, agricultural, soil, geological and meteorological maps and aerial photography.
- Aerial photography wherever necessary and feasible, and
- Ground reconnaissance including another round of serial reconnaissance for inaccessible and difficult stretches, where required.

Reconnaissance survey starts with a study of the all available maps. After study of the topographical features on the maps, a number of economical alignments feasible in a general way are selected keeping in view the following points:

(i) The alignment to take into account all the control points and to be shortened and more economical compatible with requirements of gradients and curvature.

(ii) Shape of the alignment.

(iii) Avoidance as far as possible of marshy ground, steep terrains, unstable hill features and areas subject to severe climatic conditions, flooding and inundation.

(iv) Need of connecting important villages and towns.

(v) Bridging problems, and

(vi) Need to preserve environment and maintain ecological balance.

3.2 Ground Reconnaissance Survey:

Ground reconnaissance consists of general examination of ground by walking or riding along the probable routes and collecting all available information necessary for evaluating the same. In the case of hill sections, it may be advantageous sometime to start the reconnaissance from an obligatory point situated close to the top. If an area is inaccessible for the purpose of ground reconnaissance, aerial method should be used to clear the doubts.

3.3 Reconnaissance Survey Report:

Upon Conducting ground reconnaissance for the project by walking along the probable routes and collecting all available information necessary the ground seems to be plain area terrain, no major streams or railway line crosses. Hence there is no requirement of any major structures.

Chapter - 4
DESIGN STANDARD & SPECIFICATION

Chapter -4
DESIGN STANDARD & SPECIFICATION

4.1 General

Planning and design of roads & CD structures, pedestrian facilities and street furniture are essentially based on the IRC standards and MoRT&H specifications. Whenever, the codes / standards are silent on some of the aspects, the same has been planned / designed based on sound engineering practices. Design standards relevant to the project road along with the broad list of design parameters and the relevant IRC codes / specifications have been detailed in **Table 4.1.**

Table 4.1: Design Standards

SL No.	Design Parameters	Reference Code
1.	Geometric Design Standards • Carriageway width • Shoulder • Footpath • Median • Camber • Super Elevation • Horizontal Alignment • Vertical Alignment	As per IRC: 38 - 1988, IRC: 86 - 1983 & IRC: SP : 23 – 1993
2.	Road Furniture • Road Delineators • Road Markings • Road Signs	 As per IRC: 79 – 1981 As per IRC: 35 – 1997 As per IRC: 67 – 2001
3.	Road Capacity	As per IRC: 106 – 1990
4.	Pavement Design	As per IRC: 37 – 2012 & IRC: SP 62 - 2014
5.	Overlay Design	As per IRC: 81 – 1997
6.	Road Drainage	As per IRC: SP: 42 - 1994 & IRC: SP: 50 - 1999
7.	Culverts	As per relevant IRC codes and MoRT&H

The project road section passes through plain terrain. Design standards (as appropriate) have been further elaborated under the following heads:

- Geometric Design
- Pavement Design
- Drainage
- Road Furniture and Appurtenances
- Bridges and CD Structures

4.2 Design Standards Related to Geometric Design

Design standards related to road geometric along with the suggested design values / standards and recommended values based on site conditions and data analysis are detailed in **Table 4.2**.

Table 4.2: Geometric Design Standards

SL No.	Design Parameters	Design Values
1.	Design Speed	Design speed Considered is 40 kmph.
2.	Geometric Design Standards	
	• Carriageway Width	Two lane carriageway
	• Camber (Bi-directional)	2.5% for paved carriageway.
	• Super Elevation	Limited to 4%.
	• Footpath	Minimum width - 1.5m
	• Extra Widening at Curves	Nil for Radius above 300 m
	• Gradient	Maximum Gradient - 4.0 % (1 in 25) Minimum Gradient for Drainage - 0.5 % (desirable minimum) & 0.3 % (absolute minimum).

4.3 Design Standards Related to Pavement Design

Design standards related to Flexible Pavement design are essentially based on the guidelines given in IRC: 37 - 2012 "Tentative Guidelines for the Design of Flexible Pavements " and IRC SP 62-2004 "Guidelines for the Design and Construction of Cement Concrete Pavements for Rural Roads". The suggested design values / standards and recommended values based on site conditions and data analysis are detailed in **Table 4.3** and are adapted in the design.

Table 4.3: Design Standards

SL No.	Design Parameters	Reference Code / Design Values
1.	Flexible Pavement design	IRC: 37 - 2012 " Tentative Guidelines for the Design of Flexible Pavements "
	Initial Traffic	In terms of CVPD, vehicles weighing more than 3 ton
	Traffic growth rate	5%
	Design Life	10 to 15 years
	Vehicle damage factor	1.5 to 4.5
2.	Soil Characteristics	CBR Value
3.	Rigid Pavement design	IRC SP: 62 – 2014 "Guidelines for the Design and Construction of Cement Concrete Pavements for low Volume Roads"

4.4 Design Standards Related to Overlay Design

Design standards related to Overlay design are essentially based on the guidelines given in IRC: 81 - 1997 "Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique". The suggested design values / standards and recommended values based on site conditions and data analysis are detailed in **Table 4.4** and are adapted in the design.

Table 4.4: Overlay Design Standards

SL No.	Design Parameters	Reference Code / Design Values
1.	Overlay Design	IRC: 81 - 1997 "Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique"
	• Design Life	10 years
	• Correction Factors	Temperature Correction Factor. Correction for Seasonal Variation (inclusive of correction for moisture content, soil type and rainfall)
	• Minimum Thickness	From structural considerations recommended minimum bituminous overlay thickness is 40 mm AC (minimum) or 50mm BM (as required) + 40mm BC
2.	Wearing Course Material (Options)	Bituminous Concrete with Crumb Rubber Modified Bitumen / Plastic Waste.

4.5 Design Standards Related to Road Drainage

Drainage of water from pavement surface is of paramount importance as far as preserving the road assets created by investing huge funds in addition to maintaining the structural soundness and functional efficiency of the road. Design standards related to road drainage are essentially based on the guidelines given in IRC: SP: 42 — 1994 "Guidelines on Road Drainage" and in IRC: SP: 50 - 1999 "Guidelines on Urban Drainage". The suggested design values / standards are detailed in **Table 4.5.**

Table 4.5: Design Standards Related to RoadDrainage

SI No.	Design Parameters	Design Values
1.	• Camber	1.7 - 2.5 % (bi - directional) for carriageway (camber of 3% is adopted).
	• Longitudinal Gradient	Minimum 0.3 - 0.5% for satisfactory drainage
	• Drain Type	Cast in situ RCC box drain with Precast RCC cover slab. RCC box culverts across cross roads.
	• For Existing Drains	Desilting and Rectification of Damaged Portion

4.6 Design Standards Related to Road Furniture and Appurtenances

Utility and importance of the road are greatly enhanced by installing road furniture and appurtenances at appropriate locations along the project road, which ensures improved road safety. Planning and design of road furniture and appurtenances are as per the guidelines stipulated in IRC. Detailing of each of these components has been done so as to integrate the same with the road improvement scheme. The suggested design values / standards are detailed in **Table 4.6.**

Table 4.6: Design Standards Related to Road Furniture and Appurtenances

SL No.	Design Parameters	Reference Code / Design Values
1.	Road Markings	IRC: 35 - 1997 "Code of Practice for Road Markings".
2.	Road Signs	IRC: 67 - 2001 "Code of Practice for Road Signs".
3.	Road Delineators	IRC: 79 - 1981 "Recommended Practice for Road Delineators".
4.	Pedestrian Facilities	IRC: 103 - 1988 "Guidelines for Pedestrian Facilities".

In addition to the above measures various other integral road components have been planned so as to achieve the maximum and optimal use of the carriageway with no / least interference to traffic flow at the same time ensuring adequate facilities to other road users especially pedestrians. All the encroachments, if any shall be cleared within the RoW.

4.7 Design Standards Related to Bridges and CD Structures

The design standards and loading considered for culverts and bridges are as stipulated in latest IRC codes / Special publications supplemented by appropriate MOST circulars and/or IS codes. The unsafe and/or deficient bridge and culvert structures (existing) will be rehabilitated or replaced by sound structures.

4.8 Layer standards and specification

4.8.1 Granular Sub Base

This work shall consist of laying and compacting well-graded material on prepared Subgrade in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as sub-base or lower sub-base and upper sub-base (termed as sub-base hereinafter) as necessary according to lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

Materials

The material to be used for the work shall be natural sand, crushed gravel, crushed stone, crushed slag, or combination thereof depending upon the grading required. Use of materials like brick metal, Kankar and crushed concrete shall be permitted in the lower sub-base. The material

durable, uncoated, dry and free from soft or flaky pieces and organic or other deleterious substances.

Composition of bituminous concrete pavement layers

S.No.	Grade of Mix	Grading I	Grading 2
	Nominal aggregate size	19 mm	13 mm
	Layer thickness	50- 65 mm	30 – 45 mm
	IS Sieve <mm	Cumulative % by weight of total aggregate passing	
1.	26.5 mm	100	
2.	19 mm	79 -100	100
3.	13.2 mm	59 - 79	79 -100
4.	9.5 mm	52 - 72	70 - 88
5.	4.75 mm	35 - 55	53 - 71
6.	2.36 mm	28 - 44	42 - 58
7.	1.18 mm	20 - 34	34 - 48
8.	0.60 mm	15 - 27	26 - 38
9.	0.3 mm	10 - 20	18 - 28
10.	0.15 mm	5 - 13	12 - 20
11.	0.075 mm	2 - 8	4 - 10
Bitumen content, % by weight of total mixture[1]		Min. 5.0 – 6.00 %	Min. 5.00 – 7.00 %
Bitumen grade		65*	65*

Marshall Properties Requirements for bituminous concrete layers

S.No.	Requirement of property of mix from Marshall sample	Standard
1.	Minimum stability (kN at 60°C)	9.00
2.	Minimum flow (mm)	2
3.	Maximum flow (mm)	4
4.	Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
5.	Per cent air voids	3 -6
6.	Per cent voids in mineral aggregate (VMA)	See table 9.28 below
7.	Per cent voids filled with bitumen (VFB)	65 -75
8.	Loss of stability on immersion in water at 60 C (ASTM-D-1075)	Min. 75 % retained strength

4.8.5 Dry lean concrete sub-base

1) Ordinary Portland or Portland slag or Portland puzzolana cement conforming to 15:269 IS: 455 and IS: 1489 respectively may be used. If the sub-grade contains soluble sulphate in excess of 0.5 per cent cement used shall be sulphate resistant and shall conform to IS: 6909.

2) Coarse and fine aggregates shall conform to IS: 383. If required coarse aggregate should be

washed and drained. Fine aggregate should be free from soft particles, clay, lignite, shale, loam cemented particles, mica, organic and other foreign matter.

3) Maximum size of aggregate shall be 26.5.

4) Water used for mixing and curing of concrete shall be free from injurious amounts of oil, salt, acid, vegetable matter or other substances harmful to the finished concrete. It should meet the requirements stipulated in IS:456.

5) The mix should have a maximum aggregate cement ratio of 15:1. Optimum moisture content should be determined by trial and construction should be carried out with water content between the optimum and optimum + 2 Per cent.

6) Minimum cement content shall not be less than 150 kg/cu.m of concrete.A trial length, outside main work, having a minimum length of 60 m and full width of pavement and containing at least. One transverse construction joint should be constructed to determine the optimum moisture content, density, and strength of lean concrete.

7) The concrete work should not be carried out if concrete temperature is greater than 300C. If required chilled water or ice flakes should be used.. The work should also not be carried out in adverse conditions, like, high temperature low relative humidity excessive wind velocity imminence of rain or concrete temperature below 50 C.

8) The sub-grade should be finished to proper lines grades and cross-sections. It should not be softened by rain after preparation. For areas with plastic soils, like, BC soil, the soil should be prepared with about 2 per cent of lime. The sub-grade should be given a fine spray of water and rolled one day before laying the lean concrete.

9) Batching and mixing .should preferably be carried out in a force action central batching and mixing plant. The average compressive strength of the lean concreteshould not be less than 10 MPa at seven days. In addition, the minimum compressive strength of any individual cube should not be less than 7.5 Mpa at seven days.

10) The concrete should, be transported by tipping trucks ensuring that no segregation takes place. Some practical measures for reducing segregation are listed below: i) The maximum size of the aggregates should be restricted to 25 mm. ii) While stockpiling aggregates the height of layer should be restricted to 1-2 meters and each layer should be spread horizontally. iii) Dumpers should be moved back and forth to stagger heaps. iv) Use of down-pipe from conveyor belt to dumper in reducing segregation may be considered, where applicable. v) If a paver is employed, it should be operated at moderate speed. At higher speeds, coarser fraction tends to move towards edges.

11) Concrete should be spread over the full width preferably with a paver with electronic sensors. The minimum dry density shall be 97 per cent of that achieved during the trial length construction as described below. The density achieved at 0.5 m from the edge should not be less than 95 per cent of that achieved during trial construction.

12) The time between mixing of the first batch of concrete and final finishing time should not exceed

90 minutes when the concrete temperature is between 250 C and 300 C and 120 minutes when the concrete temperature is less than 250 C. This period may be reviewed in the light of results of the trial run.

13) Mixing and placing of concrete shall progress only at such rate as to permit proper finishing, protecting and curing of the pavement.

14) 80 to 100 kN static weight are suitable for rolling dry lean concrete. In addition, to the number of passes required for compaction there should be a preliminary pass without vibration for bedding and a final pass without vibration to remove roller marks. Special care should be exercised during compaction near joints, kerbs, channels, side forms, around gullies and manholes. If necessary plate vibrators may be used at these locations.

15) Immediately after the compaction, curing should commence either by spraying with liquid curing compound and covering with wet Hessian for three days, after the compound looses tackiness, or directly covering the surface with wet Hessian kept moist for seven days.

16) As far as possible transverse joints should be at right angles to the pavement edge. Also, the transverse joints should be provided in line with the joints in the slab of the adjoining lane.

17) Sufficient forms should be available to atleast 200 metres length at all times. This should be set to the required alignment in advance of paving operation for 200 meters length or anticipated length of pavement to be laid in next 24 hours, whichever is more.

18) A separation membrane should be provided between concrete slab and sub-base to obviate stresses developing at the interface as a result of temperature changes in the concrete slab. This should be 125 microns thick impermeable plastic Sheet laid flat without creases and nailed to the lower layer with concrete nails. The overlap in plastic sheet, where necessary, should be at least 300 mm.

4.8.6 Pavement Quality Concrete

1) Ordinary Portland cement of grades 33, 43 or 53 conforming respectively to IS: 269, IS: 8112 and IS: 12269 should be used. If the soil has soluble salts, like, sulphate in excess of 0.5 percent, the cement used shall be sulphate resistant and shat conform to IS: 12330.

2) Guidance regarding matching the strength of cement with the designed strength of concrete may be obtained from IS: SP: 23, "Handbook for concrete Mixes". Cement content should be between 350 and 425 kg/cum of concrete.

3) Admixtures conforming to IS: 6925 and IS: 9103 may be used to improve workability of concrete or extension of setting time. If air entrained admixture is used, the total quantity of air-in-air entrained concrete as a percentage of the volume of the mix should be 5+1.5 per cent. The aggregate should comply with provisions of IS: 383 and in addition, should have a Los Angeles. Abrasion test value less than 35 per cent, chloride in less than 0.06 per cent by weight, Sulphuric anhydride less than 0.25 per cent by weight, water absorption less than 2 per cent and a loss of less than 12 per cent in

Chapter - 5
DESIGN & PROPOSALS

chapter deals with the design methodology adopted for the construction, strengthening and rehabilitation of the existing carriageway and the also suggests the design approach for both flexible and rigid pavement for the new carriageway. This chapter also brings out the present condition of the project corridor, the pavement option study and suggests the best alternate design.

This Section describes the studies and investigation carried out on Traffic, existing pavement conditions, existing soil sub grade condition and existing embankment / Soil at OGL condition. New pavements are generally flexible, consisting of Granular Sub-base, Water Mix Macadam and wearing course in Bituminous Concrete. Rigid pavement life span is longer (often more than 30 years) and maintenance is supposed to be less than for flexible pavement.

5.4 Pavement Design Methodology

Pavement design methodology includes two basic functions namely; design of strengthening and Widening for existing pavement and design of new crust for new Pavement to be to be adopted shall be decided based on life cycle cost analysis as a part of pavement design methodology, Accordingly, the following Methodology has been adopted in Pavement design.

Step 1: Various Pavement investigations have been carried out on the project corridor to assess the adequacy of the existing pavement crust. These investigations include:

- Visual Pavement Condition
- Visual shoulder condition
- BBD measurements
- Sub grade investigations
- Investigations on existing soil / granular layers

Step 2: Detailed material investigations have been conducted in the projected influence area and strength characteristics and availability of construction material has been determined.

Step 3: For the purpose of designing the overlay, the project corridor has been divided into homogeneous sections based on deflection measurements using Cumulative standards approach. Design thickness of overlay has been estimated from IRC-81-1997 using estimated traffic level and characteristic deflection of particular homogeneous section. Estimated BM thickness is then adjusted to equivalent thickness of BC & DBM using conversion factors given in IRC 81-1997.

Step 4: Homogeneous sections for pavement design have been established and design traffic Loadings for each of them identified. Design of flexible pavement for new road has been carried out in accordance with guidelines of IRC-37-2012.

Step 5: Design of rigid pavement has been carried out as per IRC-58-2011 method.

Step 6: Design of flexible pavement for paved shoulders, service roads, and interchange ramps has been carried out in accordance with IRC 37-2012 guidelines.

5.5 Flexible Pavement Design

5.5.1 Design CBR

Existing soil sub grade samples were collected through Trial Pit excavations at Road and shoulder interface. The existing soil sub grade were tested as per IS 2720.

The equivalent CBR is obtained as per IRC 37-2012 Chart for 905 dependability is 10%. Hence the flexible pavement design has been carried out using the IRC code (IRC-37-2012). In this code, pavement designs have been extended to cover up to 150msa and design CBR strengths up to 15%. In order to compute the damage ratio, the allowable repetitions are calculated in terms of the fatigue and rutting. The pavement design was done as per IRC-37-2012 and IIT Pave software. It accepts layer thickness, loading and material characteristics as inputs and has provisions for entering various indigenous data such as rutting and fatigue coefficients, wheel spacing, tyre pressure etc. The analysis is based on the linear elastic, multilayer theory and the stresses and strains developed in various layers of the pavement are obtained.

It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material. The California Bearing Ratio Test (CBR Test) is a penetration test developed by California State Highway Department (U.S.A.) for evaluating the bearing capacity of subgrade soil for design of flexible pavement.

Tests are carried out on natural or compacted soils in water soaked or un-soaked conditions and the results so obtained are compared with the curves of standard test to have an idea of the soil strength of the subgrade soil.

The IS Code used for CBR test of soil is IS 2720 part 16.

5.5.2 Design Life for Base and Sub-base Layers

The stage construction for first five years of pavement life is considered as an option. It would be appropriate to design the bottom non bituminous layers (base and sub-base) for axle loads expected in the 15 year design period the upper bituminous layers for axle loads expected at the end of 10 year design period. A 15-years design life has been considered for Base and Sub-base layers of flexible pavement.

5.5.3 Traffic Considerations

The base year traffic, traffic growth and the projected traffic for the design period for each category of vehicles have been arrived from the Traffic Studies. The commercial vehicle considered for the design are based on the vehicular projections considering the actual traffic, the traffic likely to be generated by future developments in the vicinity of the project road.

Further, based on the traffic studies the number of commercial vehicles has been adopted.

4.5.4 Traffic Loading

In accordance with the requirement of IRC: 37-2012, the traffic loading for the design period and design lane are to be assessed. Vehicles constituting the commercial vehicles are LCV, 2 Axles, 3 Axles and Multi Axles and Multi Axle Semi Articulated vehicles.

5.5.5 Design Approach and Criteria of Flexible pavement

Pavement distress resulting from repeated application of traffic;

- Horizontal tensile strain at the bottom of the bituminous layer
- Vertical compressive strain at the top of the Sub grade

5.5.6 Design Standards Related to Flexible Pavement Design

Design standards related to pavement design are essentially based on the guidelines given in IRC: 37-2012 – "Tentative Guidelines for Design of Flexible Pavements".

Table 5. 1 Flexible Pavement Design Standards

	Design Parameters	Reference Code / Design Values
1.	Pavement Design	IRC: 37-2012- "Tentative Guidelines for Design of Flexible Pavements"
	Traffic Growth Rate	Adopted as per IRC: 37-2012
	Design Life	Stage Construction: • 15 years for base and sub base • 8 years for bituminous layers
	Vehicle Damage Factor	Derived values based on Axle load survey. If these values are less than national average, then national average will be used.
	Lane Distribution Factor	As per IRC:37-2012
2.	Wearing Course Material (Options)	Bituminous Concrete with VG 30 (50 x 70 Grade)
3.	Mastic Asphalt	Near junctions, roundabouts and bus stops. Over major/minor bridges

5.5.7 Information required for estimating design traffic

- Initial traffic in terms of number of Commercial Vehicles per day (CVPD).
- Traffic growth rate during the design life in percentage.
- Design life in number of years.
- Spectrum of axle loads.
- Vehicle Damage Factor (VDF).

- Distribution of commercial traffic over the carriageway.

5.5.8 Computation of Design Traffic

The design traffic in terms of the cumulative number of standard axles to be carried during the design life of the road should be computed using the following equation:

$$N = \frac{365*\left[(1+r)^n - 1\right]}{r} * A * D * F$$

Where,

N = Cumulative number of repetitions in terms of million standard axles

A = Initial traffic in the year of completion of construction in terms of the number of Commercial Vehicles per Day (CVPD).

D = Lane distribution factor (as explained in Para 4.5.1 (IRC: 37-2012)

F = Vehicle Damage Factor (VDF).

n = Design life in years.

r = Annual growth rate of commercial vehicles in decimal (e g., for 5 per cent annual growth rate, r = 0.05).

Traffic Growth Rate

The present day traffic has to be projected for the end of design life at growth rates ('r') estimated by studying and analyzing the following data:

(i) The past trends of traffic growth; and

(ii) Demand elasticity of traffic with respect to macro-economic parameters (like GDP or SDP) and expected demand due to specific developments and land use changes likely to take place during design life.

If the data for the annual growth rate of commercial vehicles is not available or if it is less than 5 per cent, a growth rate of 5 per cent should be used.

The traffic in the year of completion is estimated using the following formula:

$$A = P(1+r)^n$$

Where,

P = Number of commercial vehicles as per last count.

n = Number of years between the last count and the year of completion of construction

5.5.9 Selection of Subgrade CBR for Pavement Design

The CBR values of the sub grade soil vary along a proposed alignment even on a homogeneous section. The pavement design is done based on Considering the CBR of Borrow area for

Reconstruction and Widening Section and For Existing portion the CBR of Existing Sub grade / Sub base is considered.

5.5.10 Flexible Pavement Design – Re-construction

The CBR values of the subgrade soil vary along a proposed alignment even on a homogeneous section. The pavement design is done based on Considering the CBR of Borrow area for Reconstruction and Widening Section and For Existing portion the CBR of Existing Subgrade/Sub base is taken,

5.5.11 Widening Proposals & Typical Cross Sections

a) Widening options for the project road were arrived based on,

- Lane requirements based on traffic capacity analysis.
- Requirement of service roads along built-up areas.
- Presence of religious structures.
- Availability of land

Formulation of carriageway widening schemes involves 1) estimation of extent of widening required in terms of additional lanes and 2) lateral arrangement of these additional lanes to the existing carriageway. Guidelines for the requirement of additional lanes is derived from, Traffic Study – Projected Traffic Volume vis-à-vis Capacity of each lane / road. Within the existing ROW as far as possible, and retaining the existing pavement, cross drainage structures and bridges as far as possible, without compromising the recommendations of IRC / MORT&H. Requirement of service roads along built-up areas. Additional lanes shall be added to the existing road either concentrically or eccentrically, depending on

1. The availability of right of way on either side of the existing centre line,
2. Topography and built-up areas
3. Due to specific field constraints (such as any sensitive features like water bodies, important structures etc.), localized shifting has been emerged at many places. However the actual widening will be finalized on the basis of field survey data, study of soil erosion and possibility of landslide and after completing the Environmental Assessment (EA) and Social Impact Assessments (SIA) of widening and Public Consultation.

b. Truck lay-bye and Bus bay pavement

In the case of rural areas, it is recommended to provide interlocked concrete block (M40) pavements for truck lay bye and Bus bays. An interlocked concrete block pavement resembles the structure of flexible pavement with an exception that in place of asphalt layers, cement concrete blocks are used with a levelling course of sand on top of the Base layer.

5.5.12 Design Standards Related to Rigid Pavement Design

Design standards related to pavement design are essentially based on the guidelines given in

IRC: SP 62 - 2014 – "GUIDELINES FOR DESIGN AND CONSTRUCTION OF CEMENT CONCRETE PAVEMENTS FOR LOW VOLUME ROADS".

IRC: 58 deals with design of concrete pavements for major roads carrying an average daily traffic exceeding **450 Commercial Vehicles Per Day** with laden weight exceeding **30 kN**. The guidelines contained in this document are applicable only to low volume roads with average daily traffic less than 450 Commercial Vehicles Per Day. The basic design concepts of IRC: 58 may be relevant for arriving at pavement thickness in some cases as mentioned in Clause 1.3. This document covers the design principles of rigid pavements of low volume roads 3.75 m wide (minimum 3 m wide in hills) made up of conventional concrete, roller compacted concrete and self-compacting concrete.

Table 5. 2 Rigid Pavement Design Standards

	Design Parameters	Reference Code / Design Values
1.	Pavement Design	IRC: SP 62 - 2014 – "Guidelines for design and Construction of Cement Concrete Pavements for low volume roads".
	Wheel Load	50 kN
	Tyre Pressure	0.8 MPa
	Design Period	20 years
	Traffic Growth Rate	5 %
	Design Traffic for Thickness Evaluation	For traffic less than 50 CVPD, only wheel load stresses for a load of 50 kN on dual wheel need be considered for thickness estimation since there is a low probability of maximum wheel load and highest temperature differential between the top and the bottom of the rigid pavement occurring at the same time. For traffic higher than 50 and less than 150 CVPD, thickness evaluation should be done on the basis of total stresses resulting from wheel load of 50 kN and temperature differential. For traffic exceeding 150 CVPD, fatigue can be a real problem and the guidelines consider thickness evaluation on the basis of fatigue fracture.

DESIGN OF SLAB THICKNESS

Concrete pavements are subjected to stresses due to a variety of factors and the conditions which induce the highest stress in the pavement should be considered for analysis. The factors commonly considered for design of pavement thickness are traffic loads and temperature gradients. The effects of moisture changes and shrinkage, being generally opposed to those of temperature and are of smaller magnitude, would ordinarily relieve the temperature effects to some extent and are not normally considered critical to thickness design.

For the purpose of analysis, two different regions in a pavement slab edge and corner are considered critical for pavement design. Effect of temperature gradient is very less at the corner, while it is much

higher at the edge. Concrete pavements undergo a daily cyclic change of temperature differentials, the top being hotter than the bottom during the day and opposite is the case during the night. The consequent tendency of the pavement slabs to curl upwards (top convex) during the day and downwards (top concave) during the night, and restraint offered to the curling by self-weight of the pavement induces stresses in the pavement, referred to commonly as curling stresses. These stresses are flexural in nature, being tensile, at bottom during the day, (Fig. 4.1) and at top during night (Fig. 4.2). As the restraint offered to curling at any section of the slab would be a function of weight of the slab, it is obvious that corners have very little of such restraint. Consequently the temperature stresses induced in the pavement are negligible in the corner region.

The corner tends to bend like a cantilever, giving rise to tension at the top while the tension is at bottom in case for edge loading. Deflections due to wheel loads are larger at the corner causing displacement of weaker subgrade resulting in loss of support under repeated loading and consequent corner breaking. A shorter transverse joint spacing imparts safety to a panel due to load sharing by the adjacent slabs because of better load transfer across the transverse joints since dowel bars are not recommended in low volume roads except near a permanent structure.

Wheel load stresses for interior loading are lower than those due the edge and corner loading. For low volume roads carrying a low volume of traffic, heavy vehicles are not frequent and the chance that highest axle load will act when the temperature gradient also is highest is likely to be of rare occurrence. The maximum tensile stresses in the edge region of the slab will be caused by simultaneous occurrence of wheel loads and temperature differentials. This would occur during the day at the bottom in case of interior and edge regions.

5.6 Proposed Improvements to Road Section

The proposals for the improvement of the geometric elements of the existing project road sections generally include:

a. Geometric Improvements

- Maintaining Uniform Carriageway.
- Improvements to cross sectional elements.

b. Strengthening of Existing Pavement

- Filling of potholes / damaged portion with WMM.
- Overlay for existing carriageway.
- Strengthening of Carriage way.

c. Road Drainage

- Desilting of Existing Side Drains.
- Rectification of damaged drains.
- Flagging Coarse for Existing Drain.
- Replacing damaged / Missing cover slabs.

- RCC Drains are constructed as per cast insitu method, because the area taken for improvement is developed area where the habitat is living and houses are built and connection of Electrical lines and water lines are taken for houses. The precast drain concept cannot be adopted for these areas as the houses are not built in uniform alignment and also the utilities provided to houses is not in depth. So the placing of precast drains in line and grade will be not possible. Hence Cast insitu drain is followed.

FLEXIBLE PAVEMENT OVERLAY DESIGN

DESIGN TRAFFIC:

The following equation is used to compute the design traffic in terms of the cumulative number of standard axles.

$$Ns = \frac{365 \times ((1+r)^{n}-1)}{R} \times A \times D \times F$$

Where,

Ns = Cumulative number of standard axles to be catered for in the design, MSA.

A = Initial Traffic

r = Annual growth rate of commercial vehicles

n = Design life in years

F = Vehicle Damage Factor

D= Lane distribution factor

The design traffic computed in terms of cumulative number of standard axles (msa).

City roads should be designed for minimum 2 msa traffic. (As per IRC 37 – 2012, Page No. 25, Plate 5)

The composition of pavement layers from the above Detailed Design is shown in table below. For profile correction DBM is provided and WMM in bad stretches.

Pavement compositions

Recommended for Surface course of 2 MSA		Recommended Base course of 2 MSA	
BC	**DBM**	**WMM**	**GSB**
40	Profile correction	Cut Portion	Cut Portion

Chapter - 6
TECHNICAL REPORT

Chapter - 7
PROJECT COST ESTIMATES

7.1 Detailed Cost Estimate

Detailed cost Estimate has been worked out based on detailed engineering design

7.2 General

Cost Estimate is an important part of the Report as it provides vital input to financial evaluation of the project. The cost estimates have been prepared for Strengthening of the existing road including strengthening of longitudinal drains, road furniture, site clearance and Dismantling.

7.3 Basic rates

As part of Report, Rate Analysis of each of the item has been prepared by adopting PW, P & IWTD SR 2018 - 19, Bangalore Circle. The rates as given in PW, P & IWTD SR are to be enhanced by 6% for additional weightages for the works to be executed under extra ordinary conditions for Bangalore Metropolitan Limits. Items not covered in NHSR / PW, P & IWTD SR have been based on market rates.

7.4 Project Management and Quality Control

Provision of around 2.00% of Construction Cost has been made towards Cost of DPR Preparation, Quality Control, PMC and Proof Checking.

7.5 Project Cost

The total project cost for the proposed work is 600.00 Lakh.

Detailed Cost Estimate is enclosed in **Annexure A. 7.1**

Annexure A. 1.1
KEY MAP

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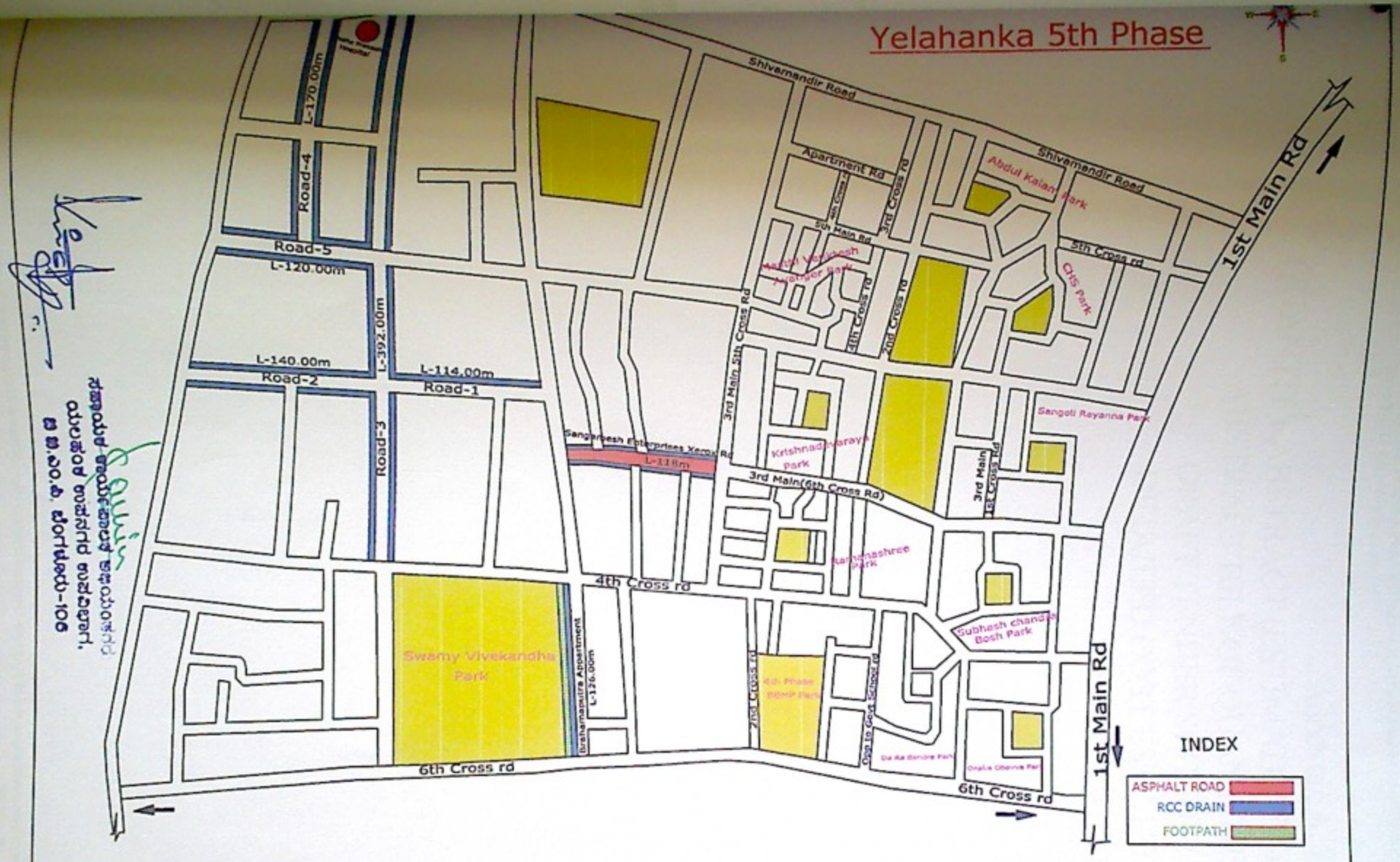
ಬೆಂಗಳೂರು-106

Consulting Engineers				Improvements To Roads and Footpaths at Yelahanka New Town 4th Phase 5th Phase and Industrial Areas in Ward no-03 of Yelahanka Sub Division (Package No-14)
Assistant Engineer	Assistant Executive Engineer	Executive Engineer		

Yelahanka 5th Phase



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Assistant Engineer | Assistant Executive Engineer | Executive Engineer

Dwg Title:
Improvements To Roads and Footpaths at Yelahanka New Town 4th Phase 5th Phase and Industrial Areas in Ward no-03 of Yelahanka Sub Division
(Package No-14)

Scale: N.T.S
Date
Dwg No.
Rev. No

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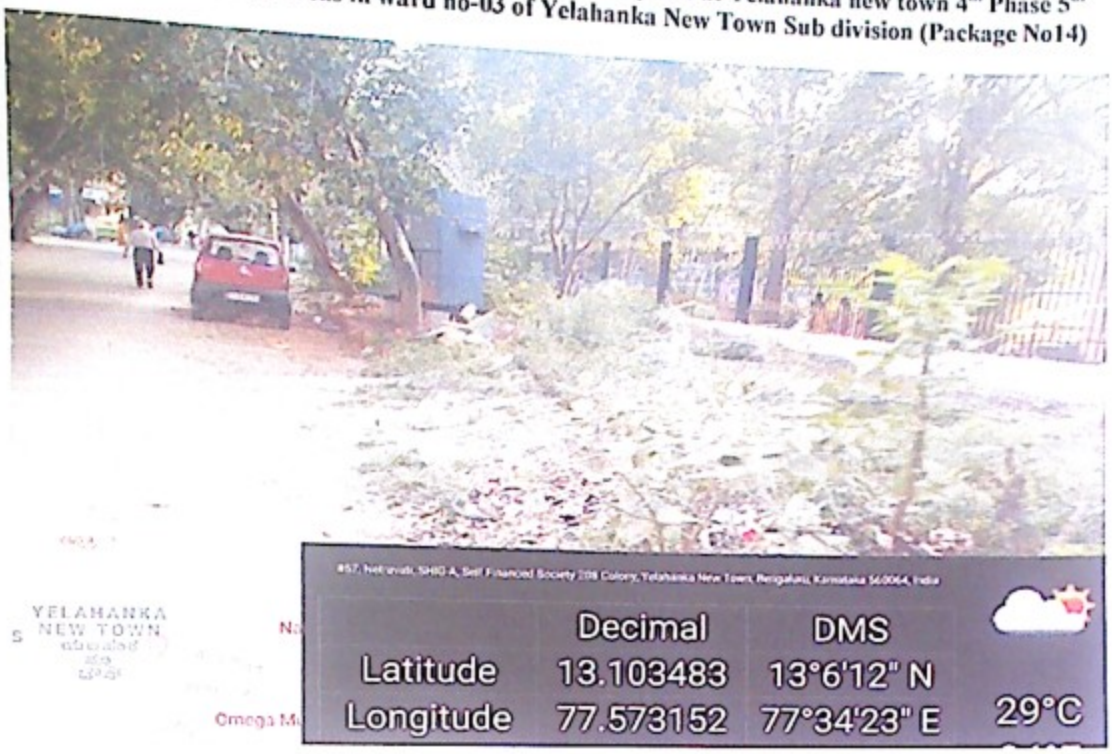

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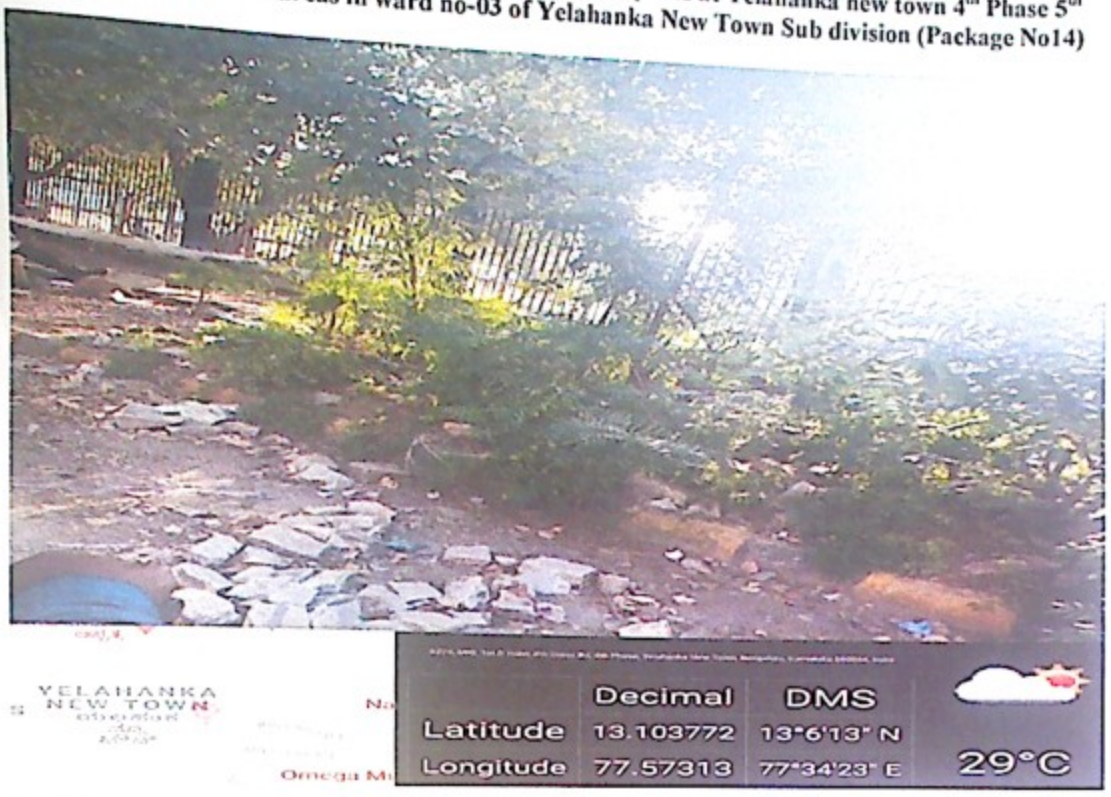

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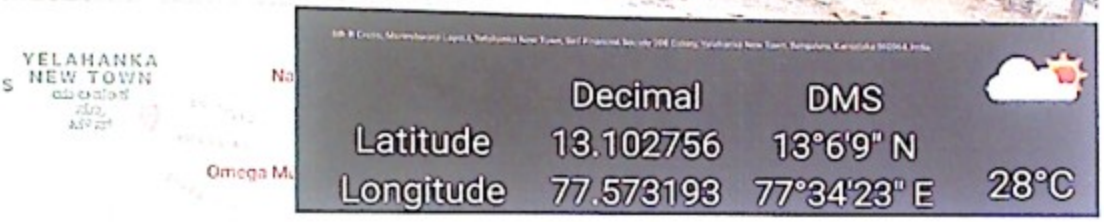

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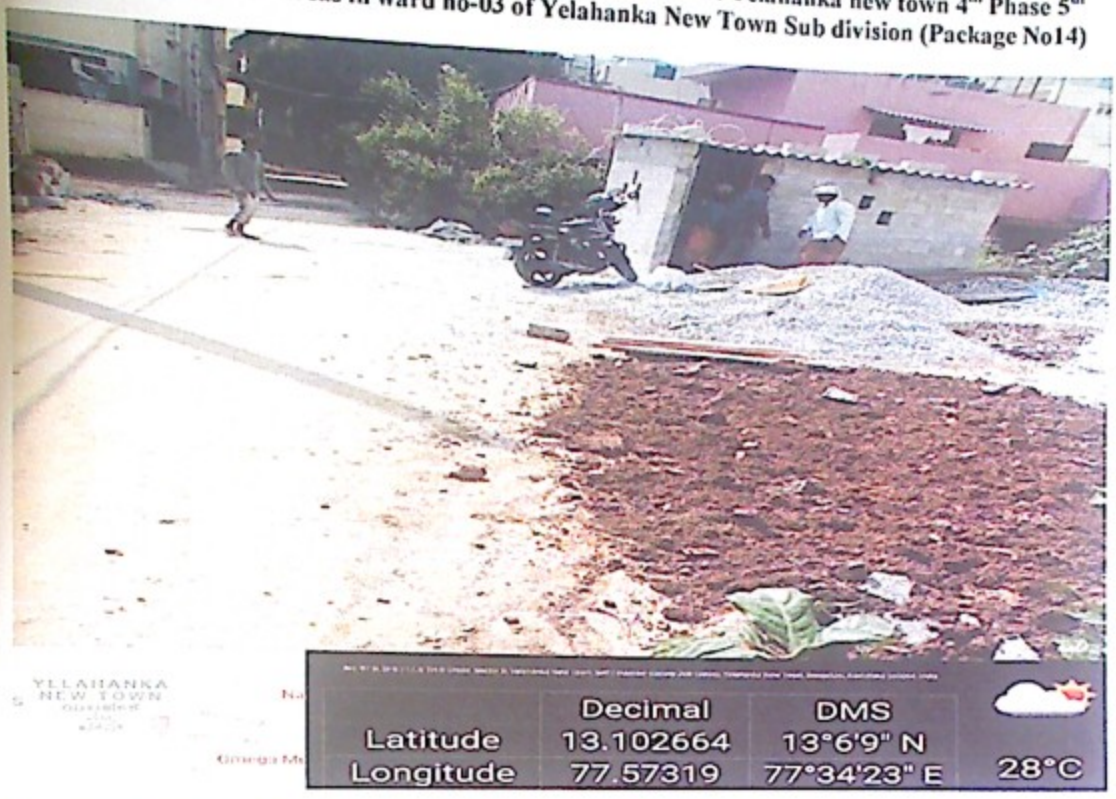

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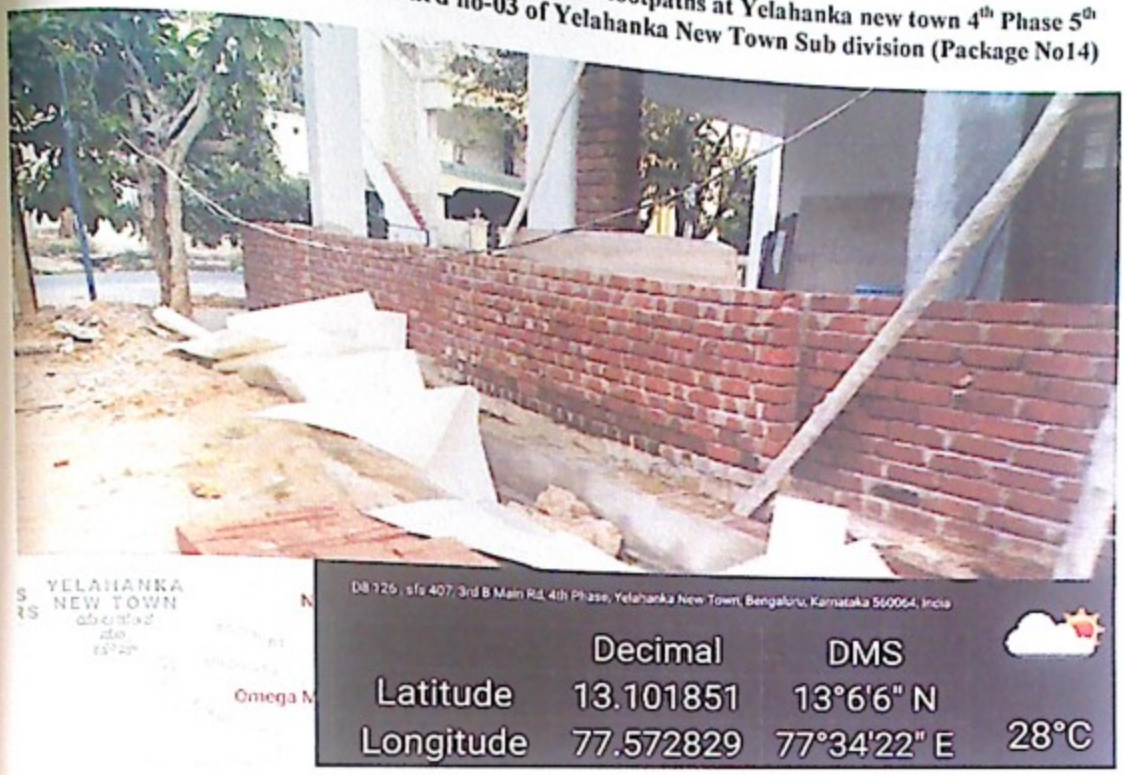

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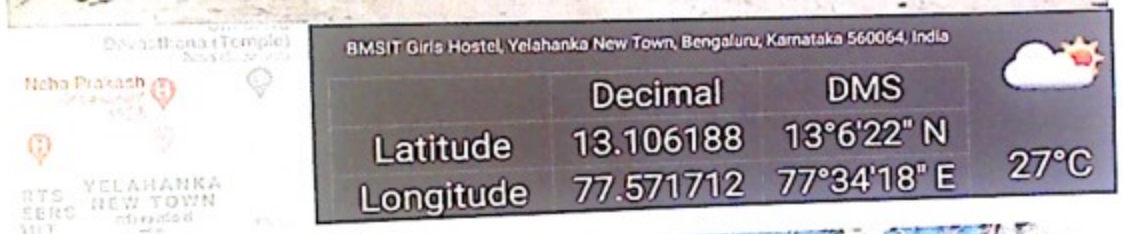

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